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# Re-defining discontinuity: Implications for the functions of dreaming

Commentary on “The continuity and discontinuity between waking and dreaming: A Dialogue between Michael Schredl and Allan Hobson concerning the adequacy and completeness of these notions”

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*Summary.* Hobson and Schredl's dialogue (2011) raised important questions concerning the operationalisation of continuity across sleep and wake, especially in contrast to discontinuity, and questioned the potential functionality of such continuity. We expand on these issues by focussing in particular upon the incorporation of different kinds of waking life experiences into dreams as both a methodological tool and a means by which the function of memory consolidation processes in sleep can be better understood. By drawing upon a theoretical framework of autobiographical memory, we propose that “discontinuity” needs to be operationalised carefully, and that a conception of discontinuity across sleep and wake can still provide insight into, and evidence for, underlying mechanisms of consolidation.

*Keywords:* Continuity hypothesis; autobiographical memory; memory consolidation; dreaming

Whilst the continuity hypothesis of dreaming seems to be receiving empirical and theoretical support within the dream research community, there is agreement that the definition and measurement of continuity is in its youth (Hobson & Schredl, 2011).

The continuity hypothesis, most broadly defined, involves some overlap between dreaming and waking (Schredl & Hofmann, 2003). This can occur at a behavioural level (featuring the incorporation of waking experiences into dreams), a cognitive level (concerning continuity of dream recall styles, memory activity etc), individual differences (personality, gender being continuous across dream and wake realms), and/or neurochemical (demonstrating continuity between particular sleep and waking states). Research into the latter has demonstrated differences as well as similarities in the activity of brain regions across sleep and wake, which have largely been interpreted as being physiologically discontinuous, and therefore a reflection of discontinuity on an experiential level, also. However continuity rather than discontinuity has been emphasised in terms of dream-wake content, behaviours and cognitive styles (see Kahan & La-Berge, 2010). It is therefore necessary to achieve two things: firstly to select carefully the states in which we are comparing physiological, behavioural, or other activity. As the waking brain is as variant and changeable as the sleeping brain over the time-course of the night, so diligent sampling of experiences is essential. Secondly, there is a real need to operationalise continuity and discontinuity, to ensure parity

in the use, measurement and understanding of these terms.

We shall focus upon one particular element of continuity: that of the incorporation of particular waking experiences into dreams. This may be conceived of as the continuity of memory activity across sleep and wake. Such experiences may be “lived” whilst awake, and re-experienced in the sleeping mind. However those experiences may also be ruminated upon, or thought and talked about in waking, as well as in the dream-world. Occasionally, experiences may be brought to mind within a dream, and experienced as a memory, rather than seemingly being “lived” out in the dream. So the continuity of memory activity is complex and bi-directional: dreams may be incorporated into our waking mentation, through either voluntary or involuntary autobiographical memory retrieval processes, and waking experiences may be incorporated into dreams. The former has been investigated in studies of dream recall, but could also be considered an important aspect of continuity. Further, some experiences from waking may be incorporated into dreams, ruminated upon in wake, and further incorporated into dreams. Thus the continuity between dreaming and waking may be cyclical as well as bi-directional.

Some systematic investigations have attempted to characterise what kinds of waking experiences feature in dreams sampled from different stages of sleep. According to Baylor and Cavallero (2001), REM dreams are less likely than non-REM dreams to contain episodic memories, which are unique experiences, specific in place and time (Conway, 2001; Tulving, 1983). Concurrently, non-REM sleep seems to selectively consolidate, or enhance retrieval for, episodic memories (Rauchs et al., 2004). Thus it could be argued that the memories activated in the sleeping brain, manifested in our dreams, reflect underlying processes of memory consolidation. REM dreams are more likely to contain self-representation (Baylor & Cavallero, 2001; Foulkes and Schmidt, 1983), and REM dreams are more elaborate and

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include a broader range of mnemonic origins, including episodic memories, general knowledge, and self-knowledge generally (Foulkes, Bradley, Cavallero, & Hollifield, 1989), likely because they are more recallable. In fact when Cavallero, Foulkes, Hollifield and Terry (1990) controlled for the length of dreams, differences between the memory sources of REM versus non-REM dreams disappeared. Thus any investigation of a potential link between memory sources of dreams and the consolidation of those memories, needs to sample both dreams and the memory sources therein most carefully, to overcome such methodological issues of recall bias.

In contrast to Baylor and Cavallero's (2001) findings, there seems to be a growing consensus that truly episodic memory sources are not a feature of dreams (Fosse, Fosse, Hobson & Stickgold, 2003; Malinowski & Horton, 2011b). This led Fosse et al. to assume a functional dissociation between dreaming and episodic memory. As previously described, memories are occasionally able to be experienced as memories within the dreaming brain, thus a conclusion of an entire inability for episodic memories to be relived is perhaps overly simplistic. Rather, the relationship between dreaming and memory activation is complex. We propose that autobiographical memory activation is a key feature of dreaming (Horton, in prep., Horton, 2011a & b; Horton & Malinowski, 2011; Malinowski & Horton, 2011a). Autobiographical memory (Conway, 2001; 2005) involves the reconstruction of personal experiences and information about the self. That is, fragments of experience can be retrieved, with or without the associated context of that experience. In dreams, it is not unlikely to find our current self in a location (context) familiar from childhood, conversing with someone who appeared within a film we watched the previous night. In such a dream, fragments of autobiographical experience are re-activated and re-bound into a seemingly bizarre experience. This may reflect both elements of continuity and discontinuity. It is important to note that despite the fragmentary and bizarre nature of autobiographical incorporation into dreams, such discontinuity may well be functional, insofar as reflecting the underlying processes of memory consolidation within the sleeping brain. Hartmann (1996; 2011) proposes that the *autoassociative* state of the dreaming brain functions to allow experiences from our waking lives to be played out in a safe environment, in dreams. Thus seemingly bizarre connections between elements from waking life are bound together in dreams, in a functional manner – according to Hartmann in terms of learning about and rehearsing experiences. We extend this idea by suggesting that this function also serves a purpose for memory and learning. Thus we must continue to investigate and understand dream discontinuity as well as continuity, and not assume that discontinuity reflects randomness or non-functionality.

Discontinuity can assumedly be defined in a similar way to continuity, as taking several possible forms: behavioural; cognitive; individual differences, neurochemical etc. Discussions of dream bizarreness have highlighted some discontinuities within dreaming cognition (Hobson, Hoffman, Helfman & Kostner, 1987) and across dream and wake (Revonsuo & Salmivalli, 1995). Malinowski & Horton (this issue) discuss how bizarreness and discontinuity seem to be independent characteristics of dreaming, thus discontinuity does not necessarily involve bizarreness.

If continuity, and discontinuity when appropriately defined, may reflect the underlying mechanisms of memory

consolidation in sleep, explicit links between the incorporation of waking autobiographical experiences into dreams and subsequent consolidation must be made. Studies have begun to highlight these links between dreaming and consolidation (Horton, in prep.; Walmsley, Tucker, Payne, Benavides & Stickgold, 2010) and this development is most welcome. Further, with waking experiences being re-activated in the sleeping brain (thus appearing as fragments of experience within a dream) in a different context to that in which it was experienced in wake, it is not surprising that episodic memories do not appear to be incorporated into dreams. The function of this could be to allow specific fragments of waking experiences to be selectively reproduced, perhaps played out in a novel or bizarre context, rendering them context-free and subsequently increasing their interrelations with other associated memory fragments (Hartmann, 1996; 2011). This may well render those fragments of autobiographical knowledge more retrievable at a later date, thus contributing to the consolidation process. Thus the discontinuity as well as the continuity again hint at a potential function of the interplay between dreams and wake – that of improving the recallability of important information.

The next step in this research exploit is to determine the means by which waking experiences are selectively incorporated into dreams. Preliminary work demonstrates that emotionality, but not necessarily stressfulness, mediate such processes (Horton, Smith & Proctor, 2011; Malinowski & Horton, 2011a). Further, there may be differences in the way that novel experiences are incorporated into dreams, compared to previously acquired knowledge or experiences (Domhoff, 2005). The time-course of incorporation of these distinct types of experiences, along with an understanding of the neuroscience and cognitive mechanisms of consolidation, can be most promising in furthering our appreciation of dream-wake continuity.

This brief commentary has emphasised the need to define and operationalise continuity as well as discontinuity, and then to identify the extent to which continuity may reflect memory consolidation processes within the sleeping brain. Concurrently, researchers need to identify whether dreaming is an integral part of the consolidation process. Even if the experience of dreaming is not found to be an essential part of the process, it certainly serves a fantastic methodological function of providing a window onto the processes of consolidation, via continuity and discontinuity.

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